Impacts of subsistence fishery on coral reef resources in the War in the Pacific National Historic Park, Guam

A report prepared for the National Park Service by

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Project Overview

The objectives of this proposed research are to:

1. Identify historical fisheries research conducted in park waters
2. Determine the spatial and temporal pattern of fishing in park waters
3. Identify the species exploited in the subsistence fishery
4. Determine the catch per unit effort (CPUE) of different fishing methods
5. Determine the contribution of each fishing method to the indirect impact of marine debris (e.g. incidence and amount of lost line or net, floats, etc.).
6. Measure the biomass of all species harvested
7. Conduct population assessments of key fishery species within the park, comparing no-take MPA areas (Piti Bomb Holes Preserve) to adjacent areas open to fishing.

Results and Discussion

Objective 1. *Identify historical fisheries research conducted in park waters.*

The historical fisheries datasets relevant to park waters consist of creel surveys available from the Guam Division of Aquatic and Wildlife Resources, and visual surveys of key reef fish species (also conducted by DAWR) to determine the effectiveness of the Piti Bomb Holes Marine Preserve. The control site for these surveys is in Asan Bay, within park waters. To date, the analysis of these data is incomplete (J. Gutierrez, DAWR, personal communication). There are no published reports of fisheries research conducted specifically in park waters.

Objective 2. *Determine the spatial and temporal pattern of fishing in park waters.*

From our own dataset of 63 survey responses (out of 97 fishers approached, roughly a 60% response rate), the temporal and spatial pattern of fishing in WAPA is quite clear. The majority of fishers (51 of 63) arrived in the early morning and left before noon. Most of them fish along Asan Cut, the channel near the western end of Asan Bay, and along Asan Beach Park (Table 1).

Table 1. Number of fishers, hours of effort, number of fish landed, mean length of fish landed, and Catch per Unit Effort (CPUE) for 6 locations in Asan Bay. Data are presented by locations, from west to east.

Location	Fishers	Effort	Fish	Mean Length (cm)	CPUE
Pipeline	8	28.0	35	14.1	1.3
Asan Beach Park	11	23.0	62	14.1	2.7
Asan Channel	25	64.5	150	16.3	2.3
East of Asan Channel	6	35.0	97	12.6	2.8
Old NPS Bldg	5	18.5	26	9.6	1.4
Adelup	8	10.0	9	9.2	0.9

Some fished the pipeline leading out to Camel Rock (see Figure 1). Camel Rock is actually the boundary of the Piti Bomb Holes Marine Preserve, and these fishers are "fishing the line" hoping to take advantage of spillover from the higher biomass within the preserve. The remainder fished to the east of Asan Cut, as far as Adelup.

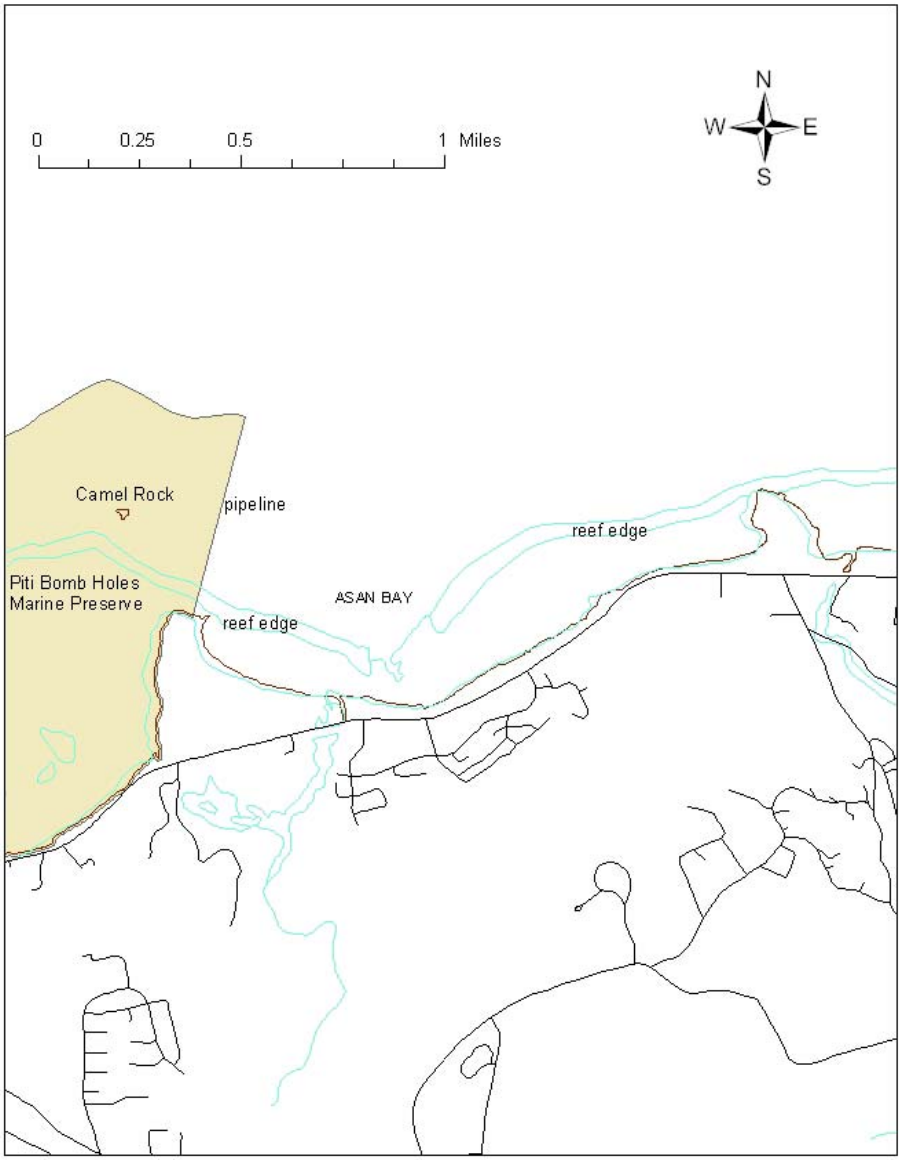

Figure 1. Map of Asan Bay. Note the channel through the reef flat in the western part of the bay. The old NPS building is roughly halfway along Asan Bay. Adelup is to the east side of the map.

Objective 3. *Identify the species exploited in the subsistence fishery.*

According to the Department of Aquatic and Wildlife Resources, the 10 most commonly exploited reef organisms along the west coast of Guam in 2002-2003 were:

1. *Naso unicornis*
2. *Naso lituratus*
3. *Chlorurus sordidus*
4. *Caranx melampygus*
5. *Kyphosus vaigiensis*
6. *Siganus spinus*
7. *Octopus cyanea*
8. *Mulloidichthys flavolineatus*
9. *Epinephelus merra*
10. *Aprion virescens*

Table 2 shows the 15 most commonly exploited reef organisms within WAPA, based on our creel surveys. The most commonly caught species were the scribbled rabbitfish, *Siganus spinus*, the octopus, *Octopus cyanea*, the velvet surgeonfish, *Acanthurus nigricans*, the bluefin trevally, *Caranx melampygus*, and assorted juvenile parrotfishes of the genus *Scarus* that could not be identified to species. The species with the highest catch per unit effort (CPUE) were *Siganus spinus, Caranx melampygus*, *Katsuwonus pelamis* (skipjack tuna), and *Kyphosus spp*. (rudderfishes). Interestingly, these fish all occurred primarily in schools, which may explain why they were easier to catch in a given time period.

Table 2. Fifteen most commonly exploited reef organisms at War in the Pacific NHP as determined by creel studies.

Species	Number	Mean Length	Effort	CPUE
Siganus spinus	66	12.4	19.5	3.33
Octopus cyanea	55	n/a	26.5	2.08
Acanthurus nigricans	42	10.0	48.0	0.88
Caranx melampygus	32	15.4	10.5	3.05
Scarus spp.	31	15.0	36.0	0.86
Acanthurus triostegus	26	7.3	10.0	2.60
Katsuwonus pelamis	26	31.3	8.0	3.25
Naso unicornis	24	13.9	30.0	0.80
Chlorurus sordidus	21	13.5	32.0	0.66
Naso lituratus	19	12.3	17.0	1.12
Naso annularis	11	19.2	15.0	0.73
Kyphosus spp.	10	16.8	4.0	2.50
Epinephelus merra	8	12.8	8.0	1.00
Gymnosarda unicolor	4	52.5	4.0	1.00
Belonus spp.	3	15.0	3.0	1.00

Objective 4. *Determine the catch per unit effort (CPUE) of different fishing methods.*

The most common fishing method by far was hook and line (Table 3). Gill nets (tekken), talaya (cast net), Hawaiian sling, and gleaning for octopus with small straight spears were roughly equal in frequency of use. A few divers went spearfishing from the shore (entering at the small channel) when the weather was calm. Offshore, fishing from boats along the reef slope involved mainly hook and line and some SCUBA spearfishing during the day, and mainly SCUBA spearfishing at night. Unfortunately, our surveyors were shore-based and could not interview people fishing from boats.

In terms of effort hours, most fishing involved either rod and reel (75 hours) or sling (59 hours), followed by gill net, cast net, straight spear, and spear gun (Table 3). Slings landed the greatest number of fish, followed by rod and reel. However, cast nets landed the highest catch per unit effort, followed by gill net, sling, rod and reel, and straight spear. No catch was reported by fishers using spearguns from the shore. We were unable to determine the CPUE of boat-based spearfishing. The higher CPUE of cast nets and gill nets is not surprising, given that nets catch multiple fish per set, compared to single fish per use with spears or hook and line.

Table 3. Number of fishers, numbers of fish caught, mean fish length, hours of effort, and Catch Per Unit Effort from creel surveys at War in the Pacific National Historic Park, Guam

Gear Type	Fishers	No. of Fish	Mean Total Length (cm)	Effort (hrs)	CPUE
Cast net	6	53	16.8	11.5	4.61
Gill net	8	67	9.9	19.5	3.44
Sling	6	139	12.4	59	2.36
Rod & reel	34	116	20.7	75	1.55
Straight spear	6	3		9.5	0.32
Speargun	3	0		2.5	0.00

Objective 5. *Determine the contribution of each fishing method to the indirect impact of marine debris (e.g. incidence and amount of lost line or net, floats, etc.).*

The most common form of debris was fishing line and hooks, which was seen on 75% (30 out of 40) of all transect censuses. However, discarded gill nets were seen on 40% (16 out of 40) of censuses, and the nets covered far more area and did more damage to the coral reef habitat than fishing line. On all occasions where discarded gill nets were observed, various invertebrates (particularly crabs) were entangled in the net and were often dead. There is inevitable some impact from fishers wading in the park and stepping on coral, but we were unable to quantify this. Floats did not appear to be a problem on the reef, although they were regularly seen washed ashore. Further research would be needed to quantify the actual impacts of this debris on the reef ecosystem and associated fisheries.

Objectives 6 and 7. *Measure the biomass of all species harvested and conduct population assessments of key fishery species within the park, comparing no-take MPA areas (Piti Bomb Holes Preserve) to adjacent areas open to fishing.*

Due to the relatively small sample sizes of each species in the creel surveys, it was not possible to estimate biomass from the catch data. Instead, we estimated biomass of common food fishes by visual estimation of total length and abundance along 50 x 5 m transects (250 m^2 coverage). Four replicate transects were deployed in the Piti Bomb Holes Marine Preserve, and four in the Asan Bay section of WAPA. Published length-weight regression for each species were applied to length and abundance data to estimate biomass of each species. The 10 most commonly observed species in our visual assessments differed somewhat from the 10 most commonly caught species from the creel surveys. This indicates that fishers do not necessarily catch the most abundant food species, but target specific, preferred species. The 10 most common species based on visual assessments were:

1. *Mulloidichthys flavolineatus*
2. *Chlorurus sordidus*
3. *Naso lituratus*
4. *Naso unicornis*
5. *Acanthurus nigricans*
6. *Acanthurus triostegus*
7. *Siganus spinus*
8. *Ctenochaetus striatus*
9. *Lutjanus gibbus*
10. *Epinephelus merra*

Based on published length-weight relationships taken from FishBase (www.fishbase.org), we estimated the biomass of these species within Asan Bay and in the adjacent Piti Bombholes Marine Preserve. For all species except *A. triostegus*, biomass was significantly higher within the Marine Preserve than in Asan Bay (one-way ANOVA, $p < 0.01$ for all species, see Figures 2 and 3 below). This indicates that the Piti Bombholes Marine Preserve is producing more and larger fish than the adjacent exploited area of Asan Bay. Please note that biomass of the most common species in Figure 2 is given in kg wet weight per 250 m^2 transect, whereas biomass of the remaining 6 species is given in grams wet weight per 250 m^2 transect.

All fishers interviewed in the creel survey were asked whether they believed the fishing in WAPA was better than, worse than, or the same as before the Piti Bomb Holes Marine Reserve was established. Of the 63 interviewees, 20 indicated that the fishing was better, 12 said it was the same, 11 said it was worse, and 20 replied that they did not know, or had no basis for comparison.

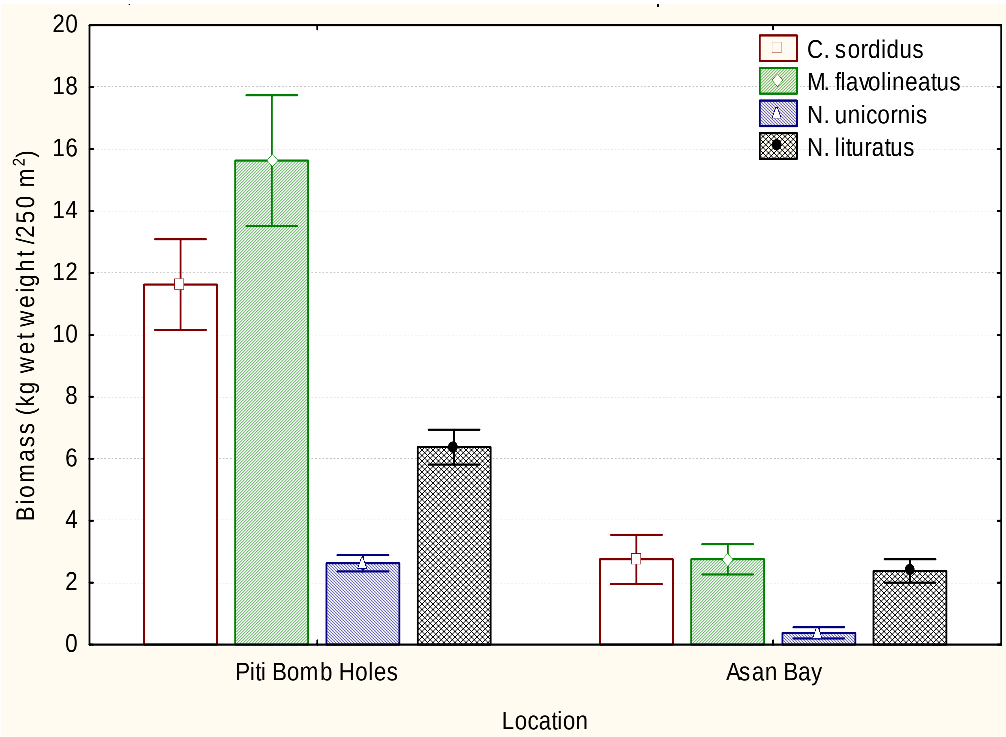

Figure 2. Mean biomass (kg) of the 4 most commonly observed reef fishes at Asan Bay, War in the Pacific NHP, and Piti Bomb Holes Marine Preserve. Error bars represent ± one standard deviation.

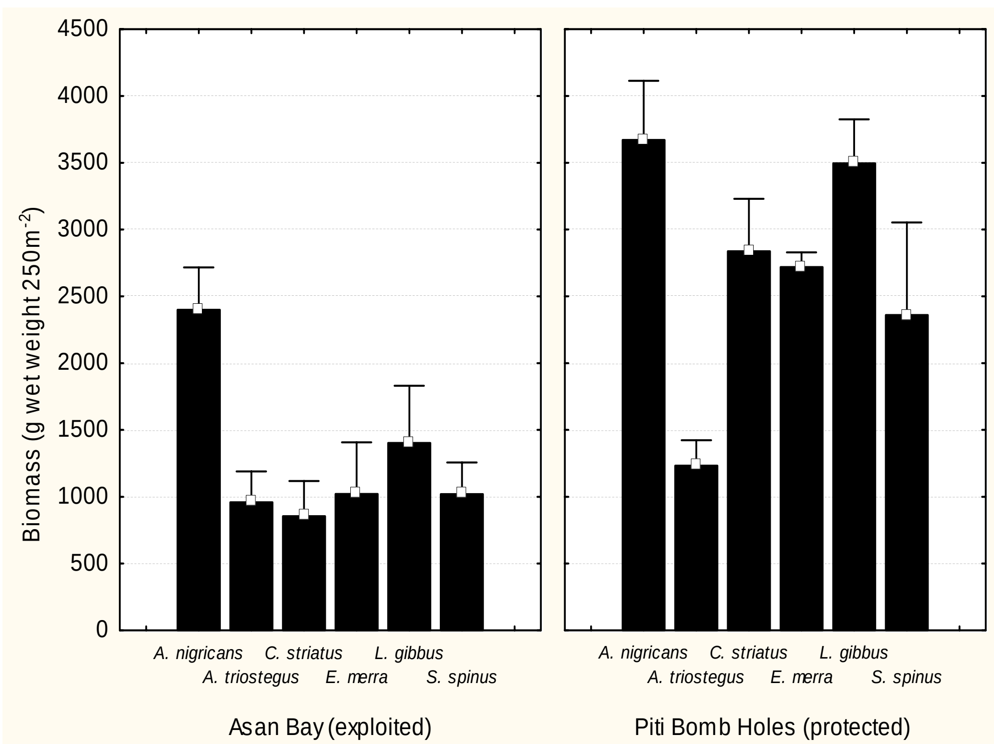

Figure 3. Mean biomass (g) of reef fishes in exploited vs. protected areas of War in the Pacific National Historical Park, Guam. Error bars represent ± one standard deviation.

Conclusions and Recommendations

In conclusion, War in the Pacific National Historic Park is subject to considerable fishing pressure from recreational and subsistence fishers. This is evidenced by the lower biomass of 9 out of 10 common reef fishes in the exploited areas of Asan Bay, as compared to the protected areas of Piti Bomb Holes Marine Preserve. Most of the fishing effort was directed at reef fish using rod and reel or Hawaiian sling, but octopus was also targeted often. The heavy fishing pressure is also resulting in degradation of the reef through discarded gear and trampling of corals, but further research is needed to determine the secondary, physical impacts of fishing on the reef ecosystem.

The Piti Bomb Holes Marine Preserve may be supplying fish biomass to Asan Bay via spillover. Fishers tended to congregate at times along the pipeline forming the boundary of the preserve. Tagging studies conducted by UOG have recently been completed in Piti and Asan Bays. These studies show that while there is no net movement of fishes across the Piti Marine Preserve boundary, larger individuals (> 25 cm) of certain species do show a net movement out of the preserve (M. Tupper, unpublished data). These species include *Caranx melampygus*, *Naso lituratus*, *Naso unicornis*, and *Lutjanus gibbus*. Additionally, the higher spawning stock biomass within the preserve may export larvae to Asan Bay, replenishing populations through larval settlement. Thus, the continuation of the Piti marine preserve as an area closed to fishing would likely be beneficial to the fishery in WAPA.

In order to better understand the fisheries of WAPA, it is recommended that this work be continued on an annual basis. It is further recommended that the results of the UOG fish tagging study from Piti and Asan Bays be incorporated into any further studies of WAPA's reef fisheries.

Appendix 1. Raw interview data

Month	Interview	Location	Gear	Target	Catch	Length	Effort (hrs)	Tide	Yield
9	1	Pipeline	straight spear	octopus	none		2	low	worse
9	2	Pipeline	rod & reel	reef fish	N. lituratus		2	ebb	don't know
9	2	Pipeline	rod & reel	reef fish	N. lituratus		2	ebb	don't know
9	2	Pipeline	rod & reel	reef fish	N. lituratus		2	ebb	don't know
9	2	Pipeline	rod & reel	reef fish	N. unicornis		2	ebb	don't know
9	2	Pipeline	rod & reel	reef fish	C. sordidus		2	ebb	don't know
9	2	Pipeline	rod & reel	reef fish	C. sordidus		2	ebb	don't know
9	3	Asan Park	Talaya	reef fish	S. scriptus		2	low	same
9	4	Channel	rod & reel	reef fish	none		0.5	low	don't know
9	5	Channel	Speargun	reef fish	none		0.5	low	don't know
9	6	Channel	straight spear	octopus	octopus		1	low	don't know
9	7	Channel	rod & reel	reef fish	N. unicornis	15	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	15	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	15	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	15	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	12.5	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	12.5	4	ebb	worse
9	7	Channel	rod & reel	reef fish	N. unicornis	12.5	4	ebb	worse
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	8	Old NPS	rod & reel	reef fish	C. melampygus	5	1.5	ebb	same
9	9	Channel	gill net	reef fish	none		0.5	ebb	don't know
9	10	Asan Park	rod & reel	reef fish	C. melampygus	5	2	ebb	better
9	10	Asan Park	rod & reel	reef fish	C. melampygus	5	2	ebb	better
9	10	Asan Park	rod & reel	reef fish	C. melampygus	5	2	ebb	better
9	10	Asan Park	rod & reel	reef fish	C. melampygus	5	2	ebb	better
10	11	Channel	rod & reel	tuna	dogtooth tuna	45	2	flood	better
10	11	Channel	rod & reel	tuna	dogtooth tuna	60	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	30	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	35	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	32	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	30	2	flood	better

Month	Interview	Location	Gear	Target	Catch	Length	Effort (hrs)	Tide	Yield
10	11	Channel	rod & reel	tuna	skipjack tuna	28	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	33	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	30	2	flood	better
10	11	Channel	rod & reel	tuna	skipjack tuna	35	2	flood	better
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	octopus	octopus		12	ebb	don't know
10	12	east of channel	Sling	reef fish	C. sordidus	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	C. sordidus	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	C. sordidus	15	12	ebb	don't know
10	12	east of channel	Sling	reef fish	C. sordidus	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	C. sordidus	12.5	12	ebb	don't know

Month	Interview	Location	Gear	Target	Catch	Length	Effort (hrs)	Tide	Yield
10	12	east of channel	Sling	reef fish	C. sordidus	20	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	17.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	16	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	15	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	15	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	12.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	13	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	20	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	15	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	15	12	ebb	don't know
10	12	east of channel	Sling	reef fish	Scarus spp.	17.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	7.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	7.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	8	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	12	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	7.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	9	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	12.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	11	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	10	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	11.5	12	ebb	don't know
10	12	east of channel	Sling	reef fish	A. nigricans	8	12	ebb	don't know
10	13	Pipeline	rod & reel	reef fish	none		2	flood	better
10	14	Adelup	rod & reel	reef fish	goby	5	2	flood	don't know
10	15	Channel	rod & reel	reef fish	E. merra	10	2	flood	same
10	15	Channel	rod & reel	reef fish	E. merra	12.5	2	flood	same
10	16	Channel	rod & reel	reef fish	none		2	flood	same
11	17	Asan Park	Talaya	reef fish	Kyphosus sp.	12.5	2	ebb	better
11	17	Asan Park	Talaya	reef fish	Kyphosus sp.	14	2	ebb	better
11	17	Asan Park	Talaya	reef fish	Kyphosus sp.	20	2	ebb	better
11	17	Asan Park	Talaya	reef fish	Kyphosus sp.	25	2	ebb	better
11	17	Asan Park	Talaya	reef fish	Kyphosus sp.	12.5	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	10	2	ebb	better

Month	Interview	Location	Gear	Target	Catch	Length	Effort (hrs)	Tide	Yield
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	10	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	10	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	20	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	20	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	15	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	15	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	17.5	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	17.5	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	17.5	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	17.5	2	ebb	better
11	18	Asan Park	Talaya	reef fish	Siganus scriptus	7.5	2	ebb	better
11	19	Channel	rod & reel	reef fish	N. lituratus	15	4	ebb	don't know
11	19	Channel	rod & reel	reef fish	N. lituratus	14	4	ebb	don't know
11	19	Channel	rod & reel	reef fish	tataga	27.5	4	ebb	don't know
11	20	Channel	gill net	reef fish	Belonus sp.	15	3	flood	better
11	20	Channel	gill net	reef fish	Belonus sp.	16	3	flood	better
11	20	Channel	gill net	reef fish	Belonus sp.	14	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	5	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	6	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	7	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	8	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	9	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	10	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	5	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	6	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	7	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	8	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	9	3	flood	better
11	20	Channel	gill net	reef fish	A. triostegus	10	3	flood	better
11	20	Channel	gill net	reef fish	Siganus scriptus	10	3	flood	better
11	20	Channel	gill net	reef fish	Siganus scriptus	10	3	flood	better
11	20	Channel	gill net	reef fish	Siganus scriptus	9	3	flood	better
11	20	Channel	gill net	reef fish	Siganus scriptus	5	3	flood	better
11	21	Channel	rod & reel	reef fish	none		2	ebb	better
11	22	Adelup	rod & reel	reef fish	none		1	flood	same

Month	Interview	Location	Gear	Target	Catch	Length	Effort (hrs)	Tide	Yield
11	23	Adelup	rod & reel	reef fish	N. lituratus	12.5	1	flood	better
11	23	Adelup	rod & reel	reef fish	N. lituratus	9	1	flood	better

Appendix 2. Catch per Unit Effort (CPUE) summary data.

Interview	Location	Gear	Target	Species	Number	Effort (hrs)	CPUE	Tide	Yield	Total CPUE
1	Pipeline	straight spear	Octopus	none	0	2	0	low	worse	0
6	Channel	straight spear	Octopus	octopus	1	1	1	low	don't know	1
12	east of channel	sling	Octopus	octopus	26	12	2.17	ebb	don't know	4.58
2	Pipeline	rod & reel	reef fish	N. lituratus	3	2	1.5	ebb	don't know	3
2	Pipeline	rod & reel	reef fish	N. unicornis	1	2	0.5	ebb	don't know	
2	Pipeline	rod & reel	reef fish	C. sordidus	2	2	1	ebb	don't know	
3	Asan Park	talaya	reef fish	S. scriptus	1	2	0.5	low	same	0.5
4	Channel	rod & reel	reef fish	none	0	0.5	0	low	don't know	0
5	Channel	speargun	reef fish	none	0	0.5	0	low	don't know	0
7	Channel	rod & reel	reef fish	N. unicornis	7	4	1.75	ebb	worse	1.75
8	Old NPS	rod & reel	reef fish	C. melampygus	6	1.5	4	ebb	same	4
9	Channel	gill net	reef fish	none	0	0.5	0	ebb	don't know	0
10	Asan Park	rod & reel	reef fish	C. melampygus	4	2	2	ebb	better	2
12	east of channel	sling	reef fish	C. sordidus	6	12	0.5	ebb	don't know	
12	east of channel	sling	reef fish	Scarus spp.	11	12	0.92	ebb	don't know	
12	east of channel	sling	reef fish	A. nigricans	12	12	1	ebb	don't know	
13	Pipeline	rod & reel	reef fish	none	0	2	0	flood	better	0
14	Adelup	rod & reel	reef fish	goby	1	2	0.5	flood	don't know	0.5
15	Channel	rod & reel	reef fish	E. merra	2	2	1	flood	same	1
16	Channel	rod & reel	reef fish	none	0	2	0	flood	same	0
17	Asan Park	talaya	reef fish	Kyphosus sp.	5	2	2.5	ebb	better	2.5
18	Asan Park	talaya	reef fish	Siganus scriptus	12	2	6	ebb	better	6
19	Channel	rod & reel	reef fish	N. lituratus	2	4	0.5	ebb	don't know	0.75
19	Channel	rod & reel	reef fish	tataga	1	4	0.25	ebb	don't know	
20	Channel	gill net	reef fish	Belonus sp.	3	3	1	flood	better	6.33
20	Channel	gill net	reef fish	A. triostegus	12	3	4	flood	better	
20	Channel	gill net	reef fish	Siganus scriptus	4	3	1.33	flood	better	
21	Channel	rod & reel	reef fish	none	0	2	0	ebb	better	0
22	Adelup	rod & reel	reef fish	none	0	1	0	flood	same	0
23	Adelup	rod & reel	reef fish	N. lituratus	2	1	2	flood	better	2
11	Channel	rod & reel	Tuna	dogtooth tuna	2	2	1	flood	better	5
11	Channel	rod & reel	Tuna	skipjack tuna	8	2	4	flood	better	

Appendix 3. Length frequency raw data

Transect	Species	Location	Total/ transect	Transect	Species	Location	Total/ transect
1	A. nigricans	Asan Bay	2511.236	1	E. merra	Asan Bay	1487.328
2	A. nigricans	Asan Bay	2818.277	2	E. merra	Asan Bay	1190.278
3	A. nigricans	Asan Bay	2188.156	3	E. merra	Asan Bay	545.2628
4	A. nigricans	Asan Bay	2081.727	4	E. merra	Asan Bay	861.5684
1	A. nigricans	PBH	3979.354	1	E. merra	PBH	2705.44
2	A. nigricans	PBH	4099.513	2	E. merra	PBH	2877.909
3	A. nigricans	PBH	3528.451	3	E. merra	PBH	2694.332
4	A. nigricans	PBH	3077.36	4	E. merra	PBH	2601.229
1	A. triostegus	Asan Bay	1218.806	1	L. gibbus	Asan Bay	1103.566
2	A. triostegus	Asan Bay	1097.925	2	L. gibbus	Asan Bay	1939.813
3	A. triostegus	Asan Bay	837.739	3	L. gibbus	Asan Bay	1604.305
4	A. triostegus	Asan Bay	681.9204	4	L. gibbus	Asan Bay	962.3644
1	A. triostegus	PBH	1527.802	1	L. gibbus	PBH	3360.87
2	A. triostegus	PBH	1163.871	2	L. gibbus	PBH	3490.007
3	A. triostegus	PBH	1153.535	3	L. gibbus	PBH	3157.744
4	A. triostegus	PBH	1083.659	4	L. gibbus	PBH	3974.576
1	C. striatus	Asan Bay	1094.824	1	S. spinus	Asan Bay	1083.081
2	C. striatus	Asan Bay	956.857	2	S. spinus	Asan Bay	1087.46
3	C. striatus	Asan Bay	911.481	3	S. spinus	Asan Bay	1246.129
4	C. striatus	Asan Bay	453.9013	4	S. spinus	Asan Bay	664.9212
1	C. striatus	PBH	2724.728	1	S. spinus	PBH	1528.718
2	C. striatus	PBH	2333.837	2	S. spinus	PBH	2626.141
3	C. striatus	PBH	3312.712	3	S. spinus	PBH	2065.1
4	C. striatus	PBH	2978.965	4	S. spinus	PBH	3224.697